What's the Difference?

Purpose

To learn how to quantitatively evaluate the accuracy of a classification

Overview

Students will classify (sort) clouds into three possible classes: cirrus, stratus, and cumulus based on their knowledge from the *Cloud Identification Protocol*. They will then compare their answers with a given set of validation data and generate a difference/error matrix. The students will then discuss how to improve their accuracy based on identifying specific mistakes they made as indicated by the difference/error matrix.

Level

Intermediate and Advanced

Time

One class period

Key Concepts

- Classification helps us organize and understand the natural world.
- In order for classification systems to be useful, we need to quantitatively determine their accuracy.
- Criteria are used to define accuracy levels.

Skills

- *Classifying* clouds
- *Evaluating* the accuracy of the classification
- *Improving* the accuracy of the classification based on the evaluation
- *Analyzing* data to understand the inter-relationships of a classification and its accuracy
- *Identifying* decision criteria for a classification system
- *Collecting* and *interpreting* validation data
- *Building* and *analyzing* a difference/error matrix for accuracy assessment
- *Solving* problems cooperatively to resolve accuracy issues

Materials and Tools

- Sets of laminated cloud pictures
- Answer key (validation data sheet)
- Procedures for this activity
- Classification Work Sheet
- Difference/error Matrix Work Sheet.

Preparation

The student work sheets need to be reproduced for each group.

Prerequisites

An activity covering the basics of classification, experience with the GLOBE *Cloud Identification Protocol*, and the *How Accurate Is it? Introducing the Difference/Error Matrix Learning Activity*

Background

Scientists classify many features of our environment, such as species of life, forest types, or soil types. While these classifications are really arbitrary human impositions on the natural world, they are also a fundamental mechanism for helping us to organize and to understand the natural world. There may be several different appropriate ways to classify a set of objects of interest. Two particular objects may be classified differently either because of error on the part of one or both of the classifiers, or simply because different classifying criteria were used. In any case, we need to know how much error is in our classification in order to use the information we have obtained with some confidence in its accuracy. Ultimately, the information generated by the classification of remotely sensed data will be used to make important decisions about global problems such as deforestation, global warming, and environmental degradation. It is imperative that we not make these decisions based on information that is inaccurate.

A difference/error matrix is the basic tool used for accuracy assessment of remotely sensed data. Its value is that it not only gives us a mechanism for generating a numerical rating of the overall accuracy of a classification or map, but it also provides a tremendous amount of information about the sources of error. This can focus our attention on those areas or classes that require it. We can use this information to improve the quality of our classification criteria, and to improve our skill at distinguishing those classes for which there is a lot of confusion. The use of cloud classification as the basis for this activity will both build upon and strengthen students' cloud identification skills from the GLOBE climate protocol.

Key Terms and Concepts

See Key Terms and Concepts under *How Accurate Is It? Introducing the Difference/Error Matrix* .

Acknowledgment

Art by Linda Isaacson.

References

National Audubon Society Pocket Guide to Clouds and Storms. New York: Alfred A. Knopf, Inc, 1995

GLOBE Cloud Chart, 1996

You may want to make an overhead of the next page with the example Cloud Classification Work Sheet and Difference/Error Matrix. The instructions are on this page.

Tallying Procedure and Overall Accuracy Calculation

For the following procedures refer to the sheet marked "example":

Step 1 For sample number 1 from the Cloud Classification Work Sheet (Table 21) determine the Student Classification cloud type (Table 21, cell A - Cirrus).

Step 2: In Table 22, the Difference/Error Matrix, find the matching student classification cloud type (cirrus) in the left-hand column.

Step 3: For sample number 1 from the Cloud Classification Work Sheet (Table 21), determine the Validation Data cloud type (Table 22, cell B - Stratus).

Step 4: In Table 22, the Difference/Error Matrix, from the cell with the identified Student Classification cloud type (cirrus), move along the row (left-to-right) until you find the category along top row which matches the Validation Data cloud type (Stratus). In the cell at the intersection between the cirrus row and the Stratus column (cell B3), tally one and move to the next sample. In this way, the rows represent the student data, and the columns represent the validation data.

Step 5: Move to sample 2 in the Cloud Classification Work Sheet and continue this process. After you have completed tallying all of the samples, you must calculate the overall accuracy.

Step 6: The total number of samples (cell D4) equals the row total (D1 + D2 + D3), which also equals the column total (A4 + B4 + C4). The total correct classifications equals the sum of the cells A1 + B2 + C3 (the major diagonal, bold-bordered cells). Divide the total correct, 1, by the total number of samples, 3. Multiply by 100 to get a percentage - 33%. This value represents the overall accuracy of the student classification.

Step 7: Just as the cells along the major diagonal represent all the "correct" classifications, the cells which are off the major diagonal represent "incorrect" classifications or differences. Hence the name difference matrix or error matrix. Each error or difference is also an *omission* from the MUC class in which it should have been classified, and a *commission* (i.e., erroneous addition) to the incorrect MUC class. This information can be used to identify cloud types that were particularly difficult to classify, and also which cloud types were confused with each other.

Table LAND-L-6: Example Cloud Classification Work Sheet

Sample Number	Photo Number	Student Classification	Validation Data	✔	X
1	3a	A: Cirrus	B: Stratus		X
2	3c	C: Stratus	D: Stratus	✔	
3	3d	E: Stratus	F: Cumulus		X

(See Validation Key, Table _____; and Figure _____:Cloud Classification Samples.)

Table LAND-L-7: Cloud Classification Difference/Error Matrix Example

Student Data		Cumulus	Stratus	Cirrus	Row Total
	Cumulus	A1:	B1:	C1:	D2: 0
	Stratus	A2: 1	B2: 1	C2:	D2: 2
	Cirrus	A3:	B3: 1	C3:	D3: 1
	Column Total	A4: 1	B4: 2	C4: 0	D4: 3

Validation Data

$$D4 = A4 + B4 + C4 = D1 + D2 + D3$$
$$\text{(column total)} = \text{(row total)}$$

$$\text{OVERALL ACCURACY} = \frac{A1 + B2 + C3}{D4} \times 100 = (1/3) \times 100 = 33\%$$

What To Do and How To Do It

1. To prepare your students, discuss with them the following questions:
   - What is the difference/error between a classification category an a classification criteria?
   - Why is classification an important activity?
   - How does classification relate to mapping?
   - Why is it important for a map to be accurate?
2. Copy and distribute the student instructions, and the numbered cloud photos.
3. Have your students follow the instructions on the work sheets to do the following steps:
   - classify the clouds into categorized by type of cloud.
   - cross reference with the validation cloud types.
   - prepare the Difference/Error Matrix.
4. Discuss with your students how this activity relates to the *Accuracy Assessment Protocol*.